TITLE: FUNDAMENTALS OF MERCURY OXIDATION IN FLUE GAS

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Objective

On December 14, 2001, the US Environmental Protection Agency (EPA) announced that it would regulate mercury emissions from coal-fired utility boilers with regulations being in place by 2007. Low cost options for controlling mercury emissions from utility boilers are extremely limited, in part due to a lack of understanding of mercury behavior in these systems. To most effectively satisfy the new regulations and remove mercury from flue gas, an adequate fundamental understanding of the system chemistry is required. The objective of this project is to understand the importance of gas-phase and solid-phase constituents to mercury oxidation reaction chemistry. To develop this understanding, the effects of chlorine, nitrogen oxide, sulfur dioxide, and ash particles on mercury oxidation will be studied. These oxidation reactions are important because oxidized mercury is effectively removed by wet flue gas desulfurization systems at no additional cost to plant operation.

Accomplishments To Date

During the current period of performance, many preparations for experimentation have been accomplished. An existing University of Utah Buck Scientific 400A mercury analyzer has been adjusted and calibrated for gas-phase mercury detection. This analyzer will be used in some of the initial drop-tube furnace experimentation. After extensive research into the current state of mercury analyzers, the decision was made to purchase a Tekran 2537A Mercury Analyzer. Negotiations have recently concluded with Randy Merritt of Southern Research Institute (SRI) to have a conditioning / speciation system designed and constructed to the specifications of SRI and ADA Environmental Systems. This conditioning system will include a PS Analytical generation / calibration unit, an

Apogee QSIS Inertial Probe, and a custom wet-chemistry system. This custom analyzer will give us more flexibility and insure greater reliability than the PS Analytical instrument. Construction and calibration of this system is to begin in early April 2004. A literature search has been conducted to find related mercury oxidation research. This information is being used to establish our testing regime. The drop tube furnace at the University of Utah has been modified with a natural gas burner to produce a representative flue gas matrix for mercury oxidation experimentation. Necessary adjustments to the safety and control scheme for the furnace are now underway. Related hardware for oxidation reaction experimentation in the drop-tube furnace has been ordered and constructed.

Future Work

Planned work for subsequent periods of this project is detailed as follows:

- Testing and Calibration of the Tekran Analyzer with SRI speciating / conditioning system.
- Utilization of the existing REI oxidation model to identify important experimental parameters using the temperature profile of the drop-tube furnace.
- Study the effects of chlorine on oxidation and also the effects of acid gasses such as nitrogen oxide and sulfur dioxide on oxidation of mercury with chlorine in the drop-tube furnace with a representative flue gas matrix.
- Identify the effects of fly ash particles, particularly calcium and iron oxide, on mercury oxidation in the entrained-flow reactor at the University of Connecticut.
- Update the REI Mercury Oxidation Model with new homogeneous rate parameters from oxidation experimentation and quantum chemistry calculations. Heterogeneous oxidation mechanisms will be added to the model using data generated by the University of Connecticut entrained flow experimentation.
- Coal combustion experimentation will be conducted on the University of Utah U Furnace for model validation.
- Feasible mercury control schemes will be evaluated using the REI Oxidation Model and U Furnace experimentation.

List of Paper Published/Conference Presentations

- Fundamentals of Mercury Oxidation in Flue Gas (Poster), Andrew R. Fry, JoAnn S. Lighty, Geoffrey D. Silcox, 18th Annual ACERC Technical Conference, 2004

Students Supported Under this Grant

- Andrew R. Fry, graduate student in the Department of Chemical Engineering, University of Utah.
- Brydger Cauch, undergraduate student in the Department of Chemical Engineering, University of Utah.